

WORKING DOCUMENT

TOTAL PHOSPHORUS SAMPLE COLLECTION AT THE S-10 AND S-39 STRUCTURES AND RECOMMENDATIONS FOR FUTURE SAMPLING

Water Quality Assessment Division
South Florida Water Management District
For June 13, 2005 Technical Oversight Committee (TOC) Meeting

Executive Summary

Flow and water quality (total phosphorus) data were retrieved for the S-10 (S-10A, S-10C, S-10D, and S-10E) and S-39 structures for the period from January 1, 2000 through December 31, 2004. The data was used to identify whether the present monitoring protocols were adequate to characterize water quality at these structures during flow events. Water quality data was also used to identify any total phosphorus (TP) gradient across these structures.

The monitoring protocols differ for the five structures and are summarized below:

- S-10A and S-10C: biweekly sampling if flowing.
- S-10D and S-39: biweekly sampling if flowing, otherwise a monthly sample is collected regardless of flow.
- S-10E: biweekly sampling if flowing, otherwise a monthly sample is collected regardless of flow; during the five-year monitoring, flow at this structure totaled 14 acre-feet (ac-ft) [Note that water quality monitoring at this site was terminated in February 2005].

Time series plots of TP and flow for each of the five structures suggest that grab samples were collected during most of the flow events (**Figures 1** through **3**). Typically, flow events lasting seven consecutive days or less were missed by the present sampling schedule at the S-10A, S-10C, and S-10D structures. However, due to the sampling protocol at S-10D, fewer of these events were missed. Flow events were more efficiently sampled at the S-39 structure. The average number of samples collected for the structures ranged from 7 per year at S-10A and S-10C to 16 per year at S-39.

Another part of the data analysis examined whether the sampling protocol was observed for these five structures. To determine whether a site was only visited with no sample collected, an additional parameter known as the “No Bottle Sample” (NOB) needed to be retrieved from the District’s database, DBHYDRO. The NOB parameter provides information when a site was visited with no sample collected. By using the NOB with the TP data, the total number of visits (or sampling opportunities) at each site can be calculated. These results are presented for each month in **Figures 4** through **6** and summarized annually in **Table 1**. With the exception of S-10E, each structure should have at least two sampling opportunities per month.

WORKING DOCUMENT

By comparing the number of sampling opportunities with the sampling protocol for each of the structures, the number of missed sampling opportunities can also be calculated (**Table 1**). The total number of missed sampling opportunities for each of the structures over the five years was three or less (**Table 1**). With the exception of these missed opportunities, the sampling protocol was observed during the entire period from 2000 through 2004.

Total phosphorus concentrations varied from structure to structure (**Figures 7 and 8**) with structures located on the northern portion of the L-39 canal (i.e., S-10E and S-10D) exhibiting higher mean TP concentrations than those in the southern portion. During the period from January 2000 through December 2004, average TP concentrations ranged from 32 µg/L at S-39 to 60 µg/L at S-10D. This gradient was also observed under flow conditions with mean TP concentrations of 30 µg/L at S-39 compared with 86 µg/L at S-10D (**Figure 8**). Additional statistical summaries of the TP data for the S-10 and S-39 structures are provided in Appendix A.

Based on the data review, additional sample collection would provide more total phosphorus information at each of the structures and would improve chances of collecting samples during short-term flow events. Cost estimates for this change are provided in Appendix B. However, there does not appear to be enough information to be gained from auto-sampling to justify this major change in approach. It is important to note that flow through the three S-10 structures occurs only a few days per month (Appendix C).

In light of these facts, consideration should be given to modifying the present sampling protocol for S-10A, S-10C, S-10D, and S39. Such a modification will require that samples be collected biweekly at each structure regardless if the structure is flowing. These changes should increase the number of samples collected at S-10A and S-10C by an average of four times and samples collected at S-10D and S-39 by twofold. In view of the relatively infrequent flow events at these structures, consistent biweekly sampling is a reasonable strategy to improve water quality information for discharges from the Refuge.

WORKING DOCUMENT

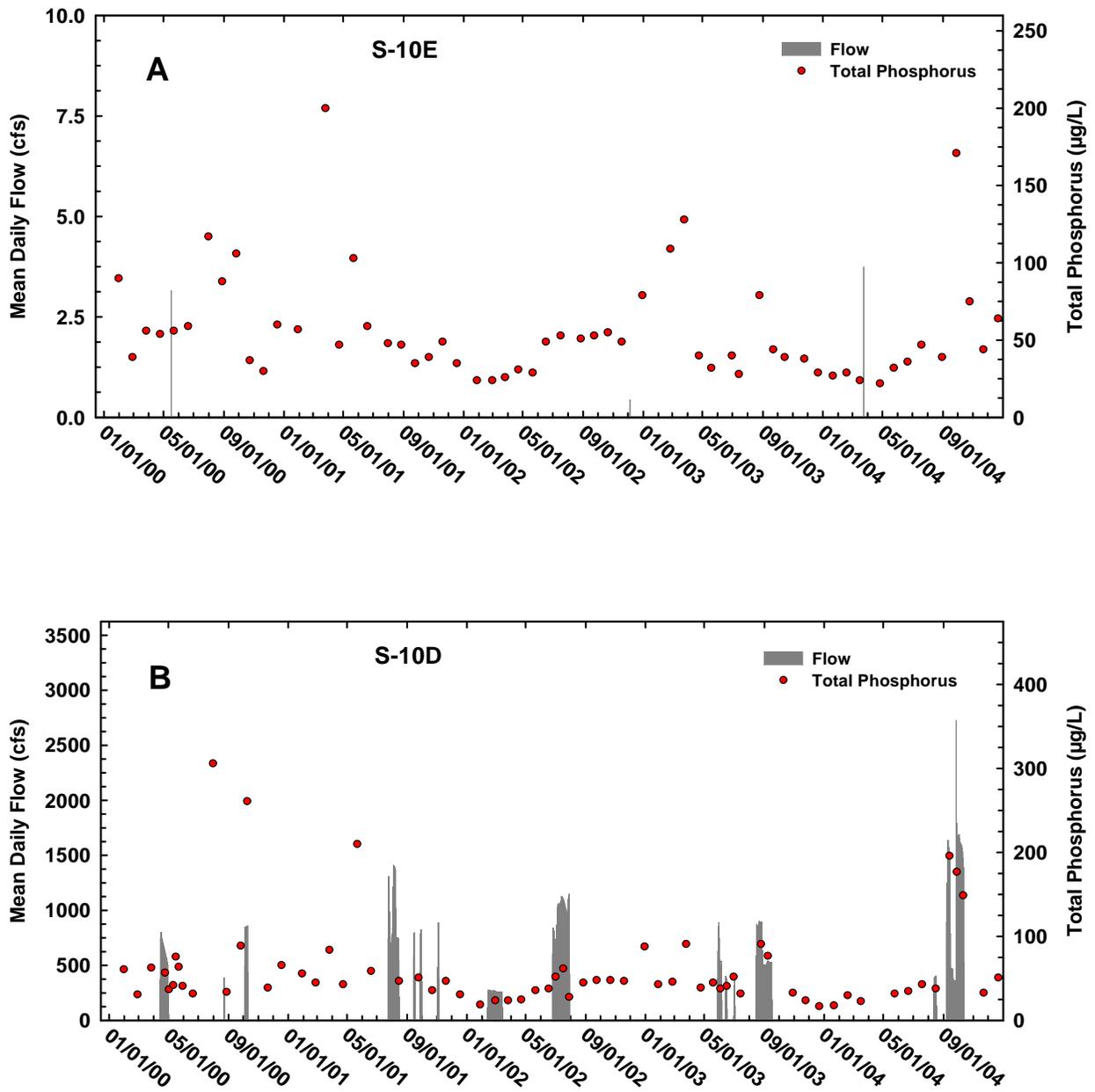


Figure 1. Mean daily flows and total phosphorus grab sample concentrations collected from January 1, 2000 through December 31, 2004 at: (A) S-10E and (B) S-10D.

WORKING DOCUMENT

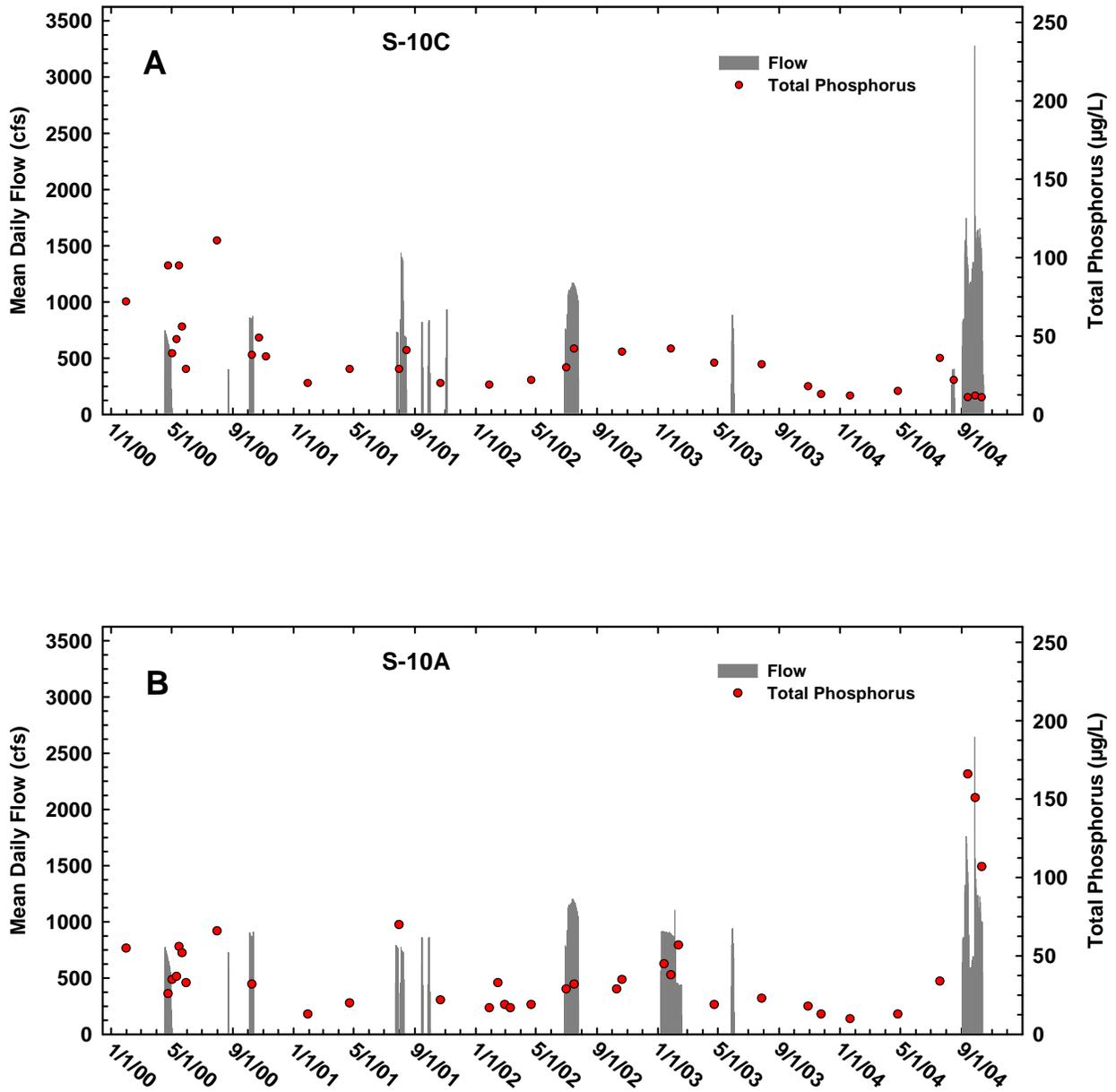


Figure 2. Mean daily flows and total phosphorus grab sample concentrations collected from January 1, 2000 through December 31, 2004 at: (A) S-10C and (B) S-10A.

WORKING DOCUMENT

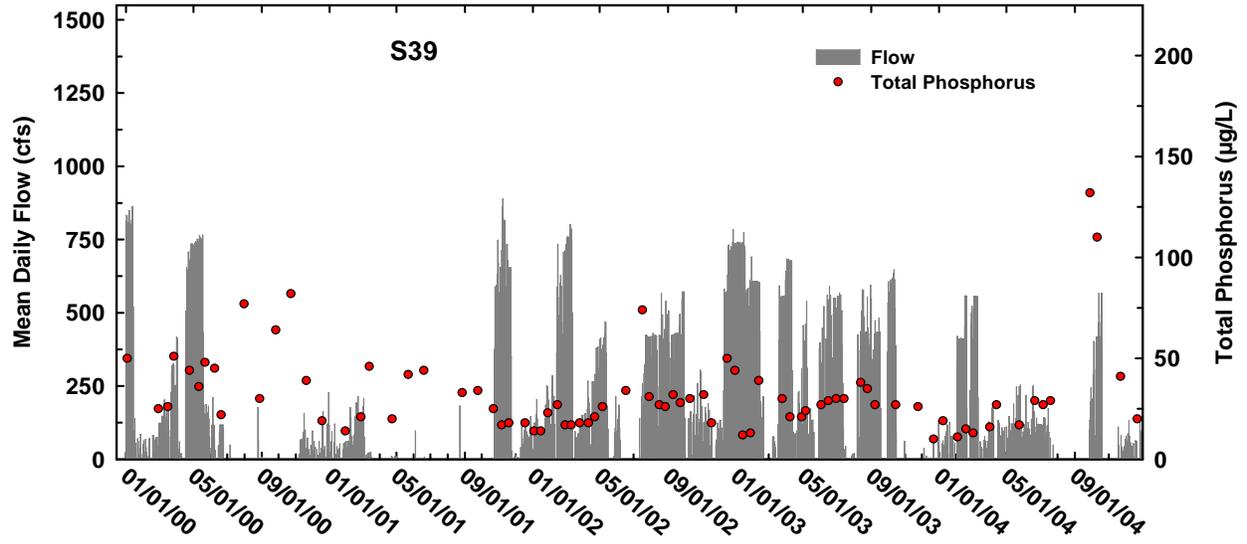


Figure 3. Mean daily flows and total phosphorus grab sample concentrations collected from January 1, 2000 through December 31, 2004 at S-39.

WORKING DOCUMENT

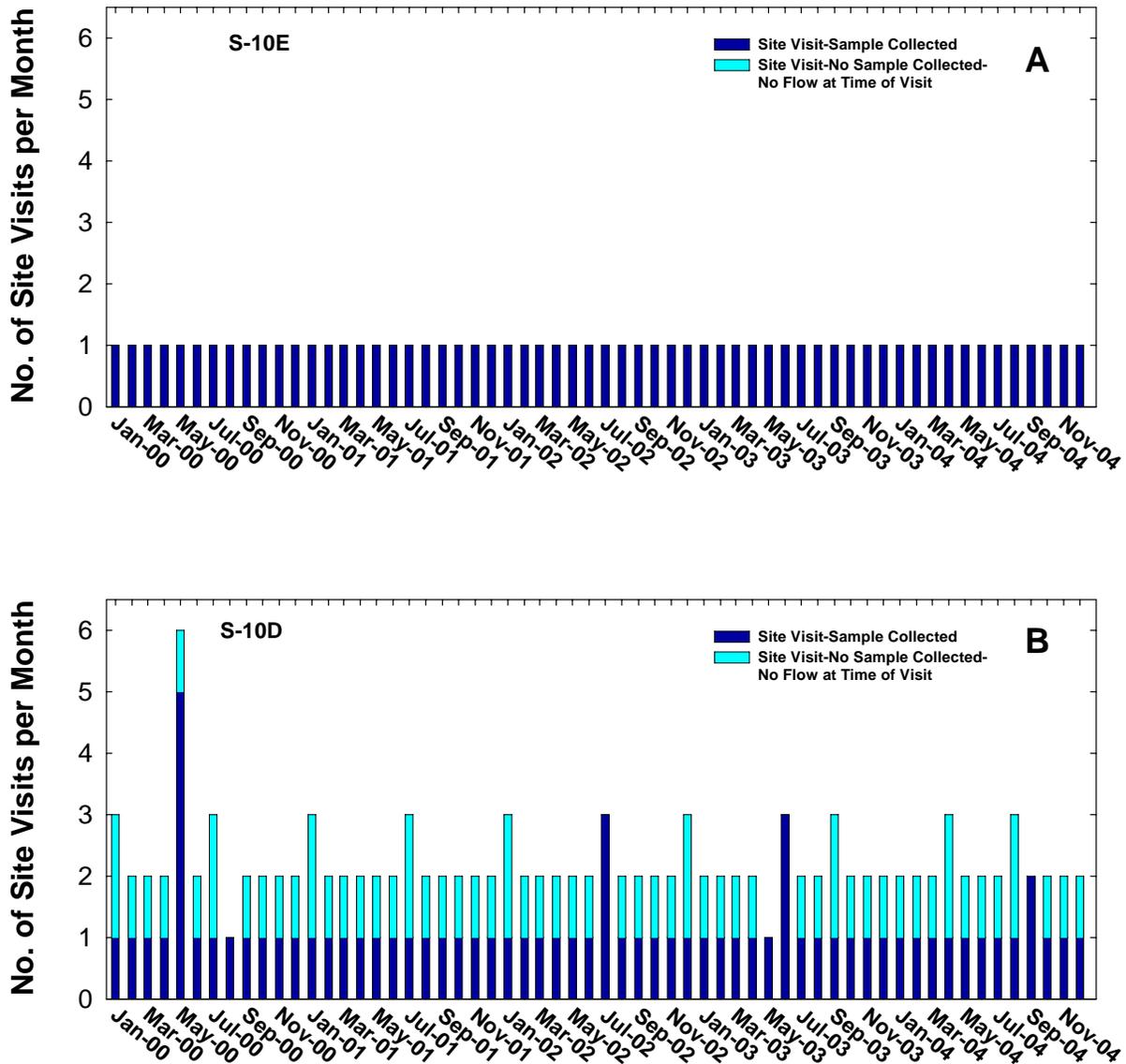


Figure 4. Stacked bar graph identifying total number of times per month Stations S-10E (A) and S-10D (B) were visited by field sampling crew from January 2000 through December 2004. The dark colored bars indicate the number of samples collected at the sites each month while the light colored bars indicate the number of times the sites was visited but no sample was collected because there was not flow at the time of the sample collection visit.

WORKING DOCUMENT

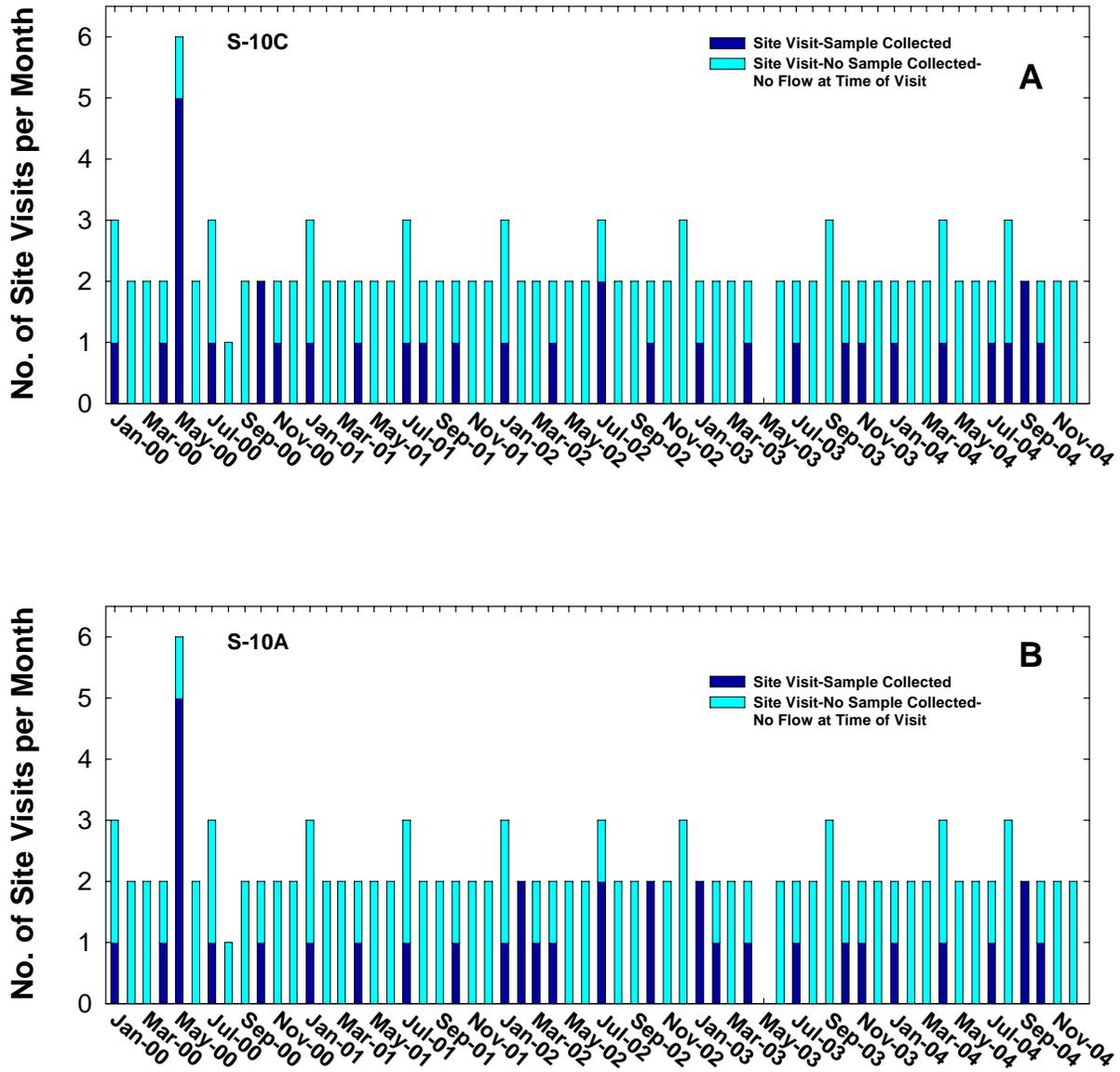


Figure 5. Stacked bar graph identifying total number of times per month Stations S-10C (A) and S-10A (B) were visited by field sampling crew from January 2000 through December 2004. The dark colored bars indicate the number of samples collected at the sites each month while the light colored bars indicate the number of times the sites was visited but no sample was collected because there was not flow at the time of the sample collection visit.

WORKING DOCUMENT

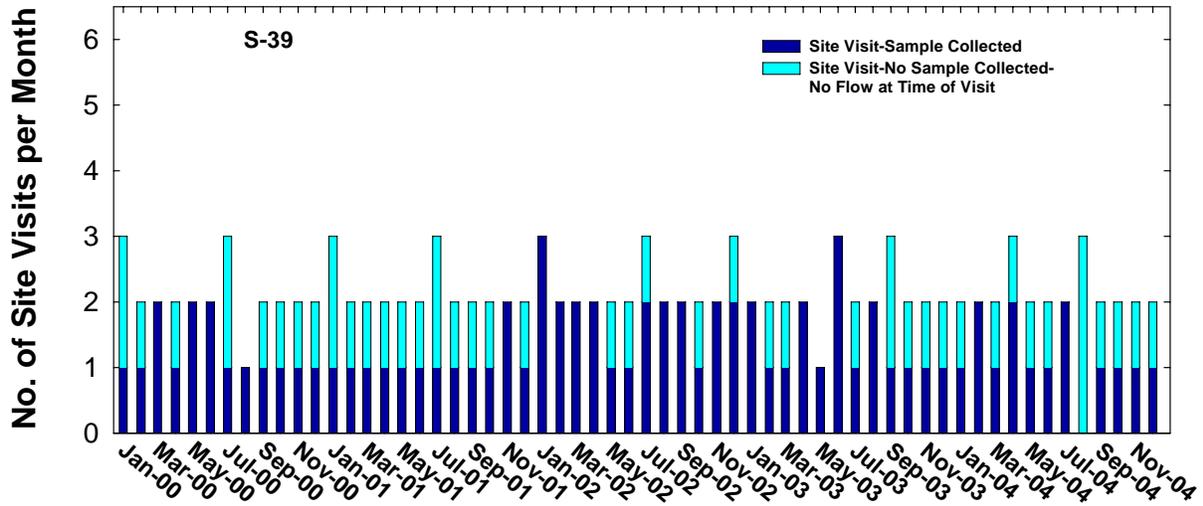


Figure 6. Stacked bar graph identifying total number of times per month Station S-39 was visited by field sampling crew from January 2000 through December 2004. The dark colored bars indicate the number of samples collected at the site each month while the light colored bars indicate the number of times the site was visited but no sample was collected because there was not flow at the time of the sample collection visit.

WORKING DOCUMENT

Table 1. Summary of flow events and monitoring performed annually at the S-10 and S-39 structures from the period from January 2000 through December 2004.

Structure	Monitoring Year	Total Number of Flow Days	Total Number of Visits to Structure	Total Number of TP Samples Collected	Number of Missed Sampling Opportunities
S10A	2000	27	29	9	1
	2001	24	26	4	0
	2002	28	27	9	0
	2003	50	23	7	2
	2004	42	26	6	0
S10C	2000	26	29	11	1
	2001	30	26	5	0
	2002	28	27	5	0
	2003	7	23	5	2
	2004	51	26	7	0
S10D	2000	28	29	16	1
	2001	37	26	12	0
	2002	67	27	14	0
	2003	52	25	14	1
	2004	44	26	13	0
S10E	2000	1	12	12	0
	2001	0	12	12	0
	2002	1	12	12	0
	2003	0	12	12	0
	2004	1	12	12	0
S39	2000	193	25	15	1
	2001	136	26	13	0
	2002	295	27	22	0
	2003	236	25	17	1
	2004	224	26	14	0

Note:

Total Number of Flow Days – Count of days during a year that flow was reported for the structure.

Total Number of Visits to the Structure – Total number of scheduled sampling events during the year that a structure was visited.

Total Number of TP Samples Collected – Number of scheduled sampling events during the year that water quality samples were collected at each structure.

Number of Missed Sampling Opportunities – Number of missed sampling events based on the monitoring protocol at each structure.

WORKING DOCUMENT

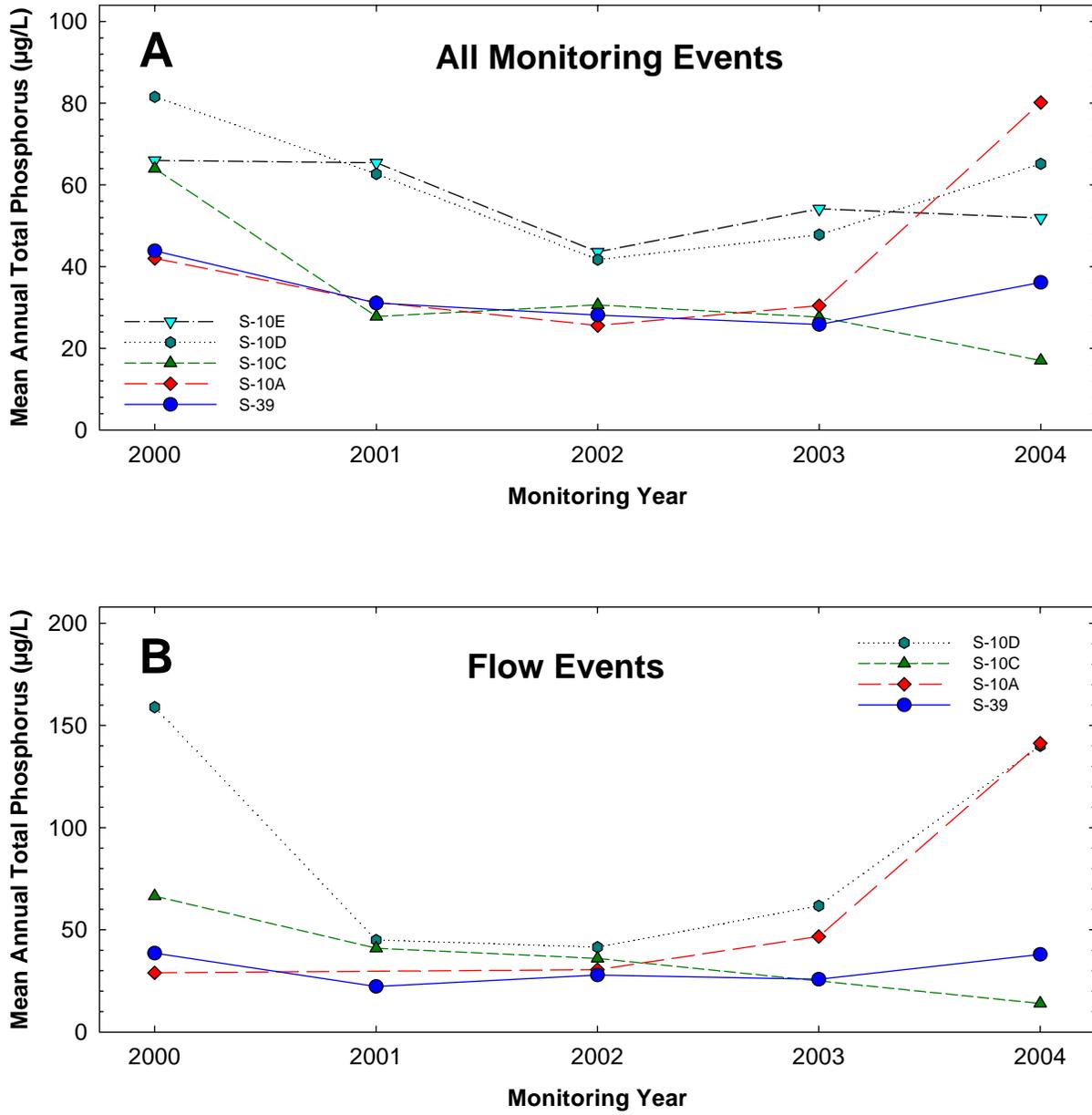


Figure 7. Mean annual total phosphorus concentrations at S-10 and S39 structures for all monitoring events (A) and flow events (B) during the period from January 2000 through December 2004.

WORKING DOCUMENT

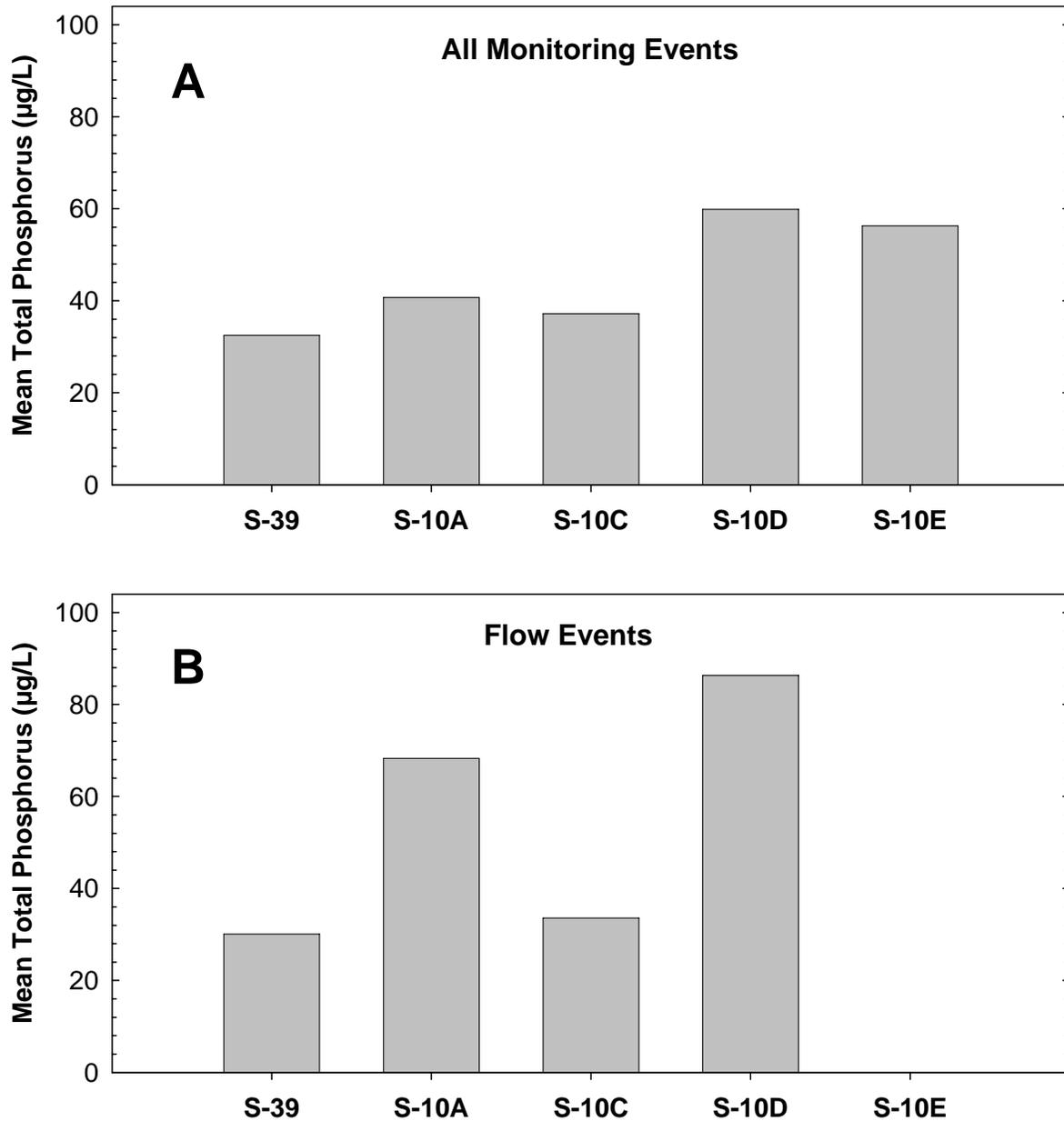


Figure 8. (A) Mean total phosphorus concentrations at the S-39 and S10 structures for samples collected under all monitoring conditions during the period from January 2000 through December 2004. (B) Mean total phosphorus concentrations at the S-39 and S10 structures for samples collected under conditions when flow was reported in DBHYDRO during the period from January 2000 through December 2004.

APPENDIX A
Summary Statistics of Flow and Total
Phosphorus at the S-10 and S-39 Structures
for the period from 2000 through 2004

WORKING DOCUMENT

**2000-2004
Flow Data**

Station	Year	No. of Flow Days	Minimum	Maximum	Median	Mean	Std. Deviation	Annual Volume (ac-ft)
S10E	2000	1	0	3	0	0	0	6
	2001	0	0	0	0	0	0	0
	2002	1	0	0	0	0	0	1
	2003	0	0	0	0	0	0	0
	2004	1	0	4	0	0	0	7
S10D	2000	28	0	859	0	49	176	35,345
	2001	37	0	1,409	0	91	281	61,339
	2002	67	0	1,147	0	126	304	83,538
	2003	52	0	899	0	82	218	59,375
	2004	45	-1622	2,724	0	122	417	88,548
S10C	2000	26	0	873	0	45	170	32,618
	2001	31	-59	1,433	0	70	246	47,562
	2002	28	0	1,169	0	84	284	55,392
	2003	7	0	883	0	12	91	8,422
	2004	52	-726	3,276	0	163	461	118,435
S10A	2000	27	0	908	0	50	185	36,530
	2001	25	-58	861	0	47	178	32,079
	2002	28	0	1,201	0	86	293	57,080
	2003	50	0	1,101	0	101	268	73,160
	2004	43	-1337	2,641	0	118	374	85,408
S39	2000	193	0	862	8	132	241	95,739
	2001	136	0	888	0	74	185	53,265
	2002	295	0	802	154	240	223	173,443
	2003	236	0	774	173	264	265	190,956
	2004	224	0	567	46	101	149	73,339

WORKING DOCUMENT

2000-2004
Total Phosphorus Data (µg/L)
All Data

STATION	YEAR	No. of Measurements	Mean	Median	Maximum	Minimum	Std Deviation
S10E	2000	12	66.0	57.5	117	30	27.9
	2001	12	65.4	48.5	200	35	46.2
	2002	12	43.6	49	79	24	16.8
	2003	12	54.2	40	128	28	33.0
	2004	11	51.9	36	171	22	42.9
S10D	2000	15	81.5	57	306	31	84.0
	2001	12	62.7	47	210	31	48.3
	2002	14	41.7	41.5	88	19	18.5
	2003	14	47.8	42	91	17	22.9
	2004	13	65.2	35	196	18	63.4
S10C	2000	10	64.0	52.5	111	37	27.4
	2001	5	27.8	29	41	20	8.6
	2002	5	30.6	30	42	19	10.3
	2003	5	27.6	32	42	13	11.8
	2004	7	17.0	12	36	11	9.2
S10A	2000	8	42.0	36	66	26	13.9
	2001	4	31.3	21	70	13	26.1
	2002	9	25.6	29	35	17	7.4
	2003	7	30.4	23	57	13	16.4
	2004	6	80.2	70.5	166	10	70.2
S39	2000	15	43.9	44	82	19	19.1
	2001	13	31.1	25	72	14	16.6
	2002	21	28.1	26	74	14	14.1
	2003	17	25.8	27	39	10	8.4
	2004	14	36.1	23.5	132	11	37.1

Note: There was one flagged TP value in 2004 at S-10E

WORKING DOCUMENT

**2000-2004
Total Phosphorus Data (µg/L)
Flow Events**

STATION	YEAR	No. of Measurements	Mean	Median	Maximum	Minimum	Std Deviation
S10D	2000	2	159	159	261	57	144.2
	2001	2	45	45	47	43	2.8
	2002	4	41.5	40	62	24	18.4
	2003	4	61.8	59	91	38	26.3
	2004	4	140	163	196	38	70.7
S10C	2000	2	66.5	66.5	95	38	40.3
	2001	1	41	41	41	41	
	2002	2	36	36	42	30	8.5
	2003	0	--	--	--	--	--
	2004	4	14	11.5	22	11	5.4
S10A	2000	2	29	29	32	26	4.2
	2001	0	--	--	--	--	--
	2002	2	30.5	30.5	32	29	2.1
	2003	3	46.7	45	57	38	9.6
	2004	3	141.3	151	166	107	30.7
S39	2000	9	38.6	44	51	22	11.6
	2001	6	22.3	18	46	14	11.8
	2002	20	27.9	26	74	14	14.4
	2003	16	25.8	27	39	10	8.7
	2004	11	38	19	132	11	41.8

Note: No significant flow was observed at S-10E during the period from January 2000 through December 2004. Total volume of water during this period was approximately 14 ac-ft.

WORKING DOCUMENT

**2000-2004
Total Phosphorus Data (µg/L)
No Flow**

STATION	YEAR	No. of Measurements	Mean	Median	Maximum	Minimum	Std Deviation
S10E	2000	12	66.0	57.5	117	30	27.9
	2001	12	65.4	48.5	200	35	46.2
	2002	12	43.6	49	79	24	16.8
	2003	12	54.2	40	128	28	33.0
	2004	11	51.9	36	171	22	42.9
S10D	2000	13	69.6	42	306	31	73.1
	2001	10	66.2	49	210	31	52.6
	2002	10	41.8	41.5	88	19	19.5
	2003	10	42.2	41	91	17	20.2
	2004	9	31.9	32	51	18	10.4
S10C	2000	8	63.4	52.5	111	37	27.1
	2001	4	24.5	24.5	29	20	5.2
	2002	3	27.0	22	40	19	11.4
	2003	5	27.6	32	42	13	11.8
	2004	3	21.0	15	36	12	13.1
S10A	2000	6	46.3	44.5	66	33	13.3
	2001	4	31.3	21	70	13	26.1
	2002	7	24.1	19	35	17	7.9
	2003	4	18.3	18.5	23	13	4.1
	2004	3	19.0	13	34	10	13.1
S39	2000	6	51.8	51.5	82	19	26.1
	2001	7	38.6	34	72	20	17.0
	2002	1	34.0	34	34	34	0.0
	2003	1	26.0	26	26	26	0.0
	2004	3	29.3	27	41	20	10.7

Note: There was one flagged TP value in 2004 at S-10E

APPENDIX B
Cost Estimates for Sampling the
S-10 and S-39 Structures

WORKING DOCUMENT

Options	Structure	Frequency	Collection Method	List of Parameters	Cost		
					Initial Cost	Annual Cost	Total Cost
Option A	Culvert S10 A	7 events (based on 5 year average) and Quarterly	Grab	Events (based on 5 years average) : ALK, CL,Color,NH4,NO2,NOX,OPO4,TKN,TP O4,TSS,TURB Quarterly : CA,K,MG,NA,SIO2,SO4,TOTFE	\$0	\$32,037	\$32,037
	Culvert S10 C	7 events (based on 5 year average) and Quarterly	Grab				
	Culvert S10 D	14 events (based on 5 year average) and Quarterly	Grab				
	S39	16 events (based on 5 year average) and Quarterly	Grab				
Option B	Culvert S10 A	Weekly	Flow Proportional Autosampler	TP	\$337,000	\$45,213	\$382,213
	Culvert S10 C	Weekly	Flow Proportional Autosampler				
	Culvert S10 D	Weekly	Flow Proportional Autosampler				
Option C	Culvert S10 A	Weekly	Time Autosampler	TP	\$81,090	\$45,213	\$126,213
	Culvert S10 C	Weekly	Flow Proportional Autosampler				
	Culvert S10 D	Weekly	Time Autosampler				
Option D	Culvert S10 C	Weekly	Flow Proportional Autosampler	TP	\$27,000	\$30,733	\$57,733
Option E	Culvert S10 A	Every other week	Grab	Every other week: ALK, CL,Color,NH4,NO2,NOX,OPO4,TKN,TP O4,TSS,TURB Quarterly : CA,K,MG,NA,SIO2,SO4,TOTFE	\$0	\$39,486	\$39,486
	Culvert S10 C	Every other week	Grab				
	Culvert S10 D	Every other week	Grab				
	S39	Every other week	Grab				

WORKING DOCUMENT

Option C

Installation of one Flow Proportional Autosampler unit at S10C and two time auto sampler units at S10A and S10 D

Frequency of sampling : Weekly

Culvert	Instrumentation Cost	Installation Cost	Annual Maintenance cost	Platform	Electricity Cost	Parameter	Annual Data Collection Cost	Annual Analytical Cost	Annual QA/QC Cost	Annual Reporting Cost	Total Cost
Culvert 10A	\$3,500	\$10,000	\$5,000	\$13,500	\$0	TP		\$640	\$800	\$800	
Culvert 10C	\$3,500	\$10,000	\$5,000	\$13,500	\$0	TP		\$640	\$800	\$800	
Culvert 10D	\$3,500	\$10,000	\$5,000	\$13,500	\$0	TP		\$640	\$800	\$800	
Total Cost	\$10,500	\$30,000	\$15,000	\$40,500	\$0		\$23,493	\$1,920	\$2,400	\$2,400	\$126,213

One time cost \$81,090
Annual Cost \$45,213

WORKING DOCUMENT

Option D

Installation of one Flow Proportional Autosampler unit at S10C

Frequency of sampling: Weekly

Culvert	Instrumentation Cost	Installation cost	Annual Maintenance Cost	Platform	Parameter	Annual Data Collection Cost	Annual Analytical Cost	Annual QA/QC Cost	Annual Reporting Cost	Total Cost
Culvert 10C	\$3,500	\$10,000	\$5,000	\$13,500	TP		\$640	\$800	\$800	
Total Cost	\$3,500	\$10,000	\$5,000	\$13,500	TP	\$23,493	\$640	\$800	\$800	\$57,733

One time cost \$27,000
 Annual Cost \$30,733

WORKING DOCUMENT

Option E

Grab sample collection every other week

Frequency of sampling:	Culvert 10A	Every other week
	Culvert 10C	Every other week
	Culvert 10D	Every other week

Culvert	Annual Data Collection cost	Annual Analytical Cost	Annual QA/QC cost	Annual Reporting cost	Total Annual Cost
Culvert 10A		\$2,398	\$800	\$800	
Culvert 10C		\$2,398	\$800	\$800	
Culvert 10D		\$2,398	\$800	\$800	
S39		\$2,399	\$800	\$800	
Total Cost	\$23,493	\$9,593	\$3,200	\$3,200	\$39,486

Annual Cost **\$39,486**

Parameters	
(Qrtly)	Every other Week
CA	ALK
K	CL
MG	Color
NA	NH4
SIO2	NO2
SO4	NOX
TOTFE	OPO4
	TKN
	TPO4
	TSS
	TURB

WORKING DOCUMENT

S10 A

Parameters	Unit Cost	Frequency of Sampling			Cost Analytical	
		Average for 5 years	Purposed		Average for 5 years	Purposed
ALK	\$6.53	7	26		\$46	\$169.78
CL	\$8.07	7	26		\$56	\$209.82
COLOR	\$6.53	7	26		\$46	\$169.78
NH4	\$6.53	7	26		\$46	\$169.78
NOX	\$6.53	7	26		\$46	\$169.78
NO2	\$6.53	7	26		\$46	\$169.78
OPO4	\$6.53	7	26		\$46	\$169.78
TKN	\$12.26	7	26		\$86	\$318.76
TPO4	\$9.14	7	26		\$64	\$237.64
TSS	\$7.77	7	26		\$54	\$202.02
TURB	\$6.53	7	26		\$46	\$169.78
CA	\$8.13	4	4		\$33	\$32.52
K	\$8.13	4	4		\$33	\$32.52
MG	\$8.13	4	4		\$33	\$32.52
NA	\$8.13	4	4		\$33	\$32.52
SIO2	\$8.25	4	4		\$33	\$33.00
TOTFE	\$19.73	4	4		\$79	\$78.92
Total Cost					\$823	\$2,398.70

WORKING DOCUMENT

S10 C

Parameter	Unit Cost	Frequency of Sampling			Cost Analytical	
		Average for 5 years	Purposed		Average for 5 years	Purposed
ALK	\$6.53	7	26		\$46	\$169.78
CL	\$8.07	7	26		\$56	\$209.82
COLOR	\$6.53	7	26		\$46	\$169.78
NH4	\$6.53	7	26		\$46	\$169.78
NOX	\$6.53	7	26		\$46	\$169.78
NO2	\$6.53	7	26		\$46	\$169.78
OPO4	\$6.53	7	26		\$46	\$169.78
TKN	\$12.26	7	26		\$86	\$318.76
TPO4	\$9.14	7	26		\$64	\$237.64
TSS	\$7.77	7	26		\$54	\$202.02
TURB	\$6.53	7	26		\$46	\$169.78
CA	\$8.13	4	4		\$33	\$32.52
K	\$8.13	4	4		\$33	\$32.52
MG	\$8.13	4	4		\$33	\$32.52
NA	\$8.13	4	4		\$33	\$32.52
SIO2	\$8.25	4	4		\$33	\$33.00
TOTFE	\$19.73	4	4		\$79	\$78.92
Total Cost					\$823	\$2,398.70

WORKING DOCUMENT

S10 D

Parameter	Unit Cost	Frequency of Sampling			Cost Analytical	
		Average for 5 years	Purposed		Average for 5 years	Purposed
ALK	\$6.53	14	26		\$91	\$169.78
CL	\$8.07	14	26		\$113	\$209.82
COLOR	\$6.53	14	26		\$91	\$169.78
NH4	\$6.53	14	26		\$91	\$169.78
NOX	\$6.53	14	26		\$91	\$169.78
NO2	\$6.53	14	26		\$91	\$169.78
OPO4	\$6.53	14	26		\$91	\$169.78
TKN	\$12.26	14	26		\$172	\$318.76
TPO4	\$9.14	14	26		\$128	\$237.64
TSS	\$7.77	14	26		\$109	\$202.02
TURB	\$6.53	14	26		\$91	\$169.78
CA	\$8.13	4	4		\$33	\$32.52
K	\$8.13	4	4		\$33	\$32.52
MG	\$8.13	4	4		\$33	\$32.52
NA	\$8.13	4	4		\$33	\$32.52
SIO2	\$8.25	4	4		\$33	\$33.00
TOTFE	\$19.73	4	4		\$79	\$78.92
Total Cost					\$1,403	\$2,398.70

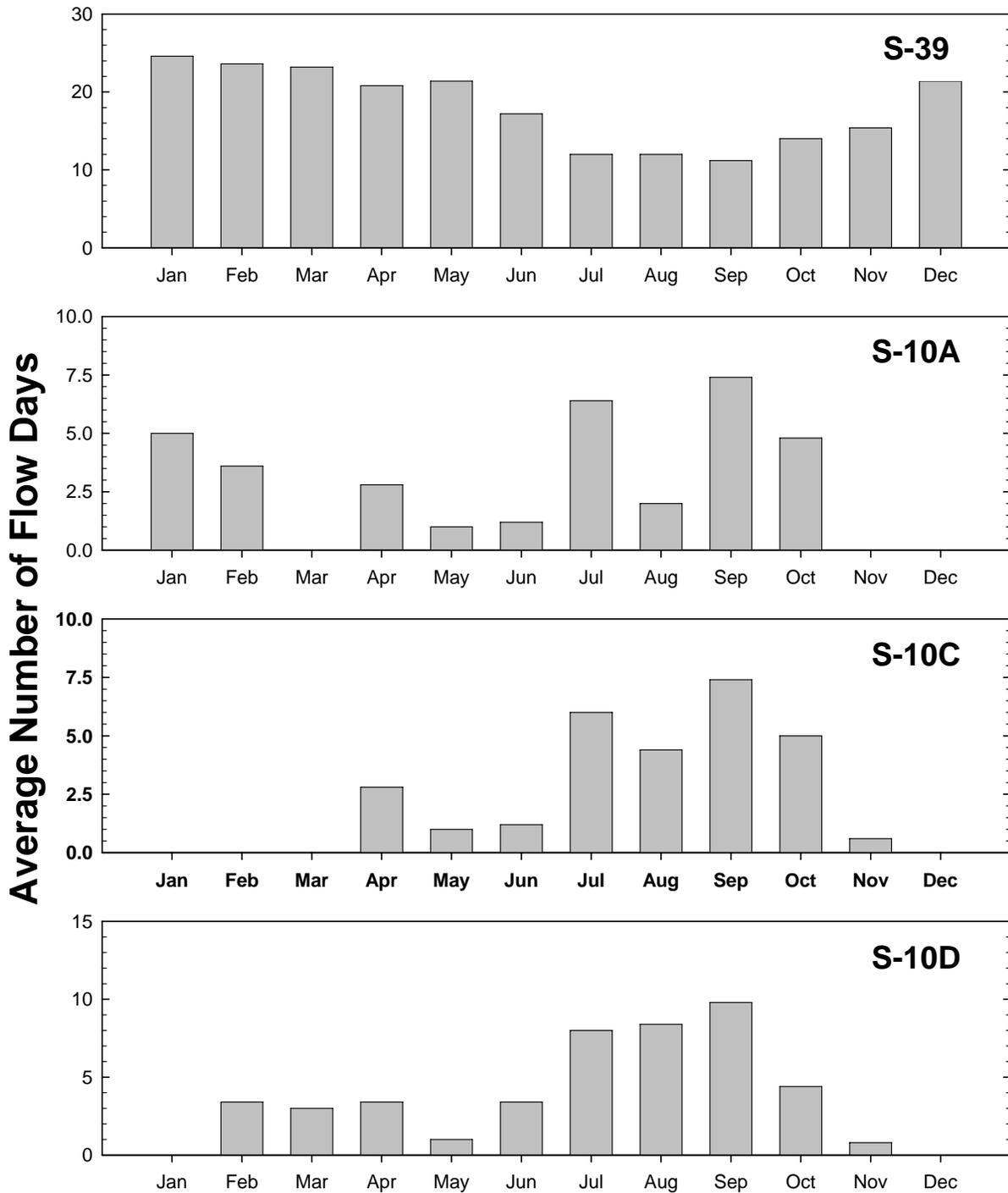
WORKING DOCUMENT

S39

Parameter	Unit Cost	Frequency of Sampling			Cost Analytical	
		Average for 5 years	Purposed		Average for 5 years	Purposed
		Average for 5 years	Purposed			
ALK	\$6.53	16	26		\$104	\$169.78
CL	\$8.07	16	26		\$129	\$209.82
COLOR	\$6.53	16	26		\$104	\$169.78
NH4	\$6.53	16	26		\$104	\$169.78
NOX	\$6.53	16	26		\$104	\$169.78
NO2	\$6.53	16	26		\$104	\$169.78
OPO4	\$6.53	16	26		\$104	\$169.78
TKN	\$12.26	16	26		\$196	\$318.76
TPO4	\$9.14	16	26		\$146	\$237.64
TSS	\$7.77	16	26		\$124	\$202.02
TURB	\$6.53	16	26		\$104	\$169.78
CA	\$8.13	16	4		\$130	\$32.52
K	\$8.13	16	4		\$130	\$32.52
MG	\$8.13	16	4		\$130	\$32.52
NA	\$8.13	16	4		\$130	\$32.52
SIO2	\$8.25	16	4		\$132	\$33.00
TOTFE	\$19.73	16	4		\$316	\$78.92
Total Cost					\$2,295	\$2,398.70

APPENDIX C
Flow Days for the
S-10 and S-39 Structures

WORKING DOCUMENT



Average number days flow was recorded at the S-10 and S-39 structures over the period from January 2000 through December 2004.